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# Coil Handling for Assembly Purposes

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# Outline



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- Assembly requirements & constraints
- Prior Experience
- SQXF coil handling assembly concept
- Summary



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# Assembly Requirements, Coilpack Handling



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- Impregnated Coil Parameters
  - OD: 226.7 mm; ID: 149.5 mm
  - Length:
    - SQXF: 1.5 m
    - LQXF: 4.3 m
  - Weight:
    - SQXF ~130 lbs / 60 kg
    - LQXF ~375 lbs / 170 kg
- Handling operation requirements
  - Single coils, bore-side down
  - Single coils, bore-side up
  - Coil pairs, bore-side down
  - Coil pairs, bore-side up
  - Eliminate manual coil flipping operations
  - Accommodate and install alignment keys & shims, Ground Plain Insulation (GPI) at assembly
  - Accommodate bore-side instrumentation (SGs, etc.) at assembly



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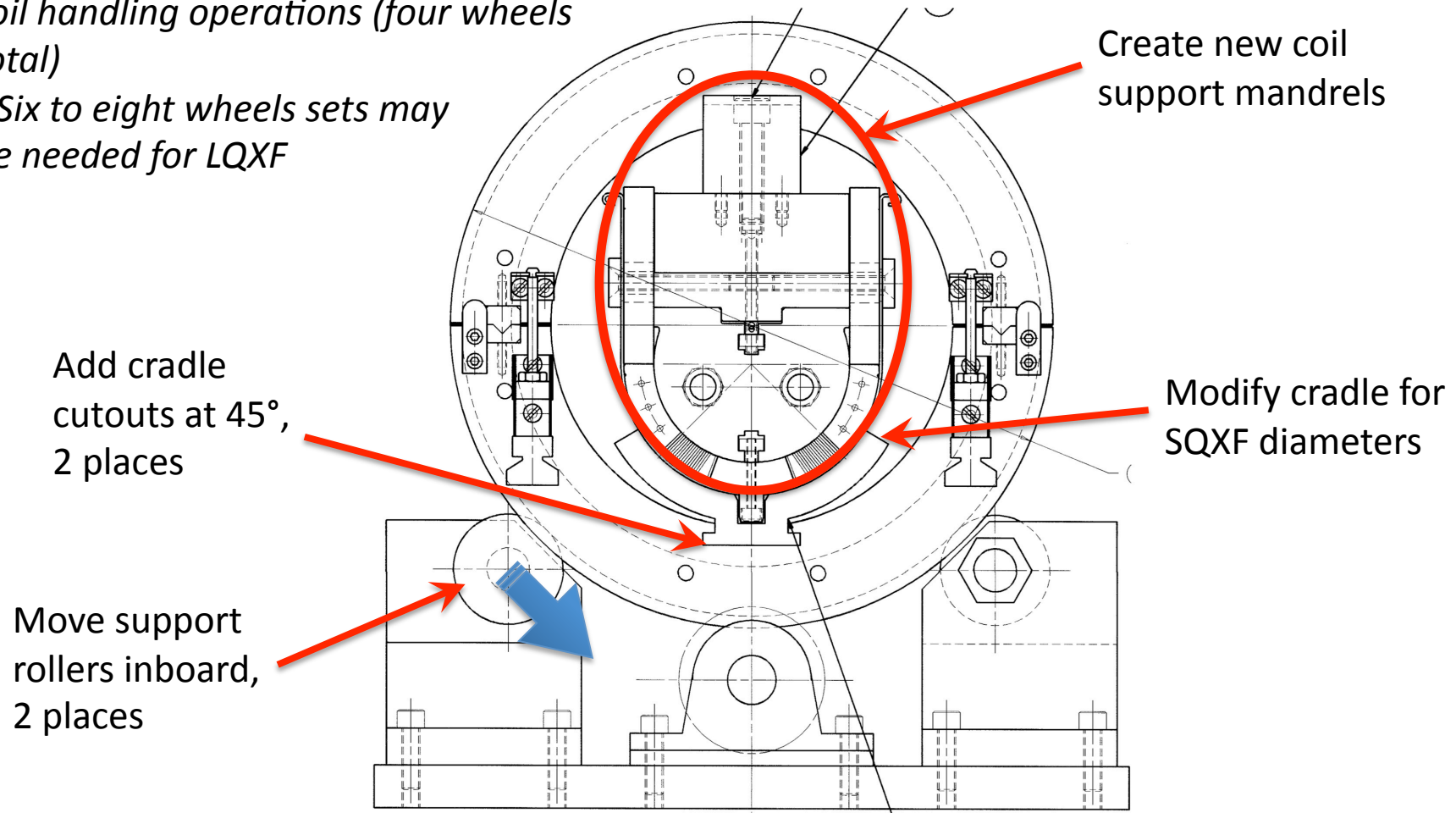
# LARP Magnet Assembly Experience



- Tooling and processes developed from prior magnets
  - Based on experience from TQS, HQ, LR, LQ
- Utilizes already-designed tooling
  - FNAL rollover tooling designs, with some design modifications
  - Existing lifting hardware (SQXF, LQ, etc.)
- Differences expected in QXF assemblies:
  - GPI installation will be incorporated in these coils
  - SQXF handling tooling should be scalable towards LQXF and production assemblies

# FNAL Coil Rollover Tool Modifications

- *Two wheel set pairs required for SQXF coil handling operations (four wheels total)*
- *Six to eight wheels sets may be needed for LQXF*



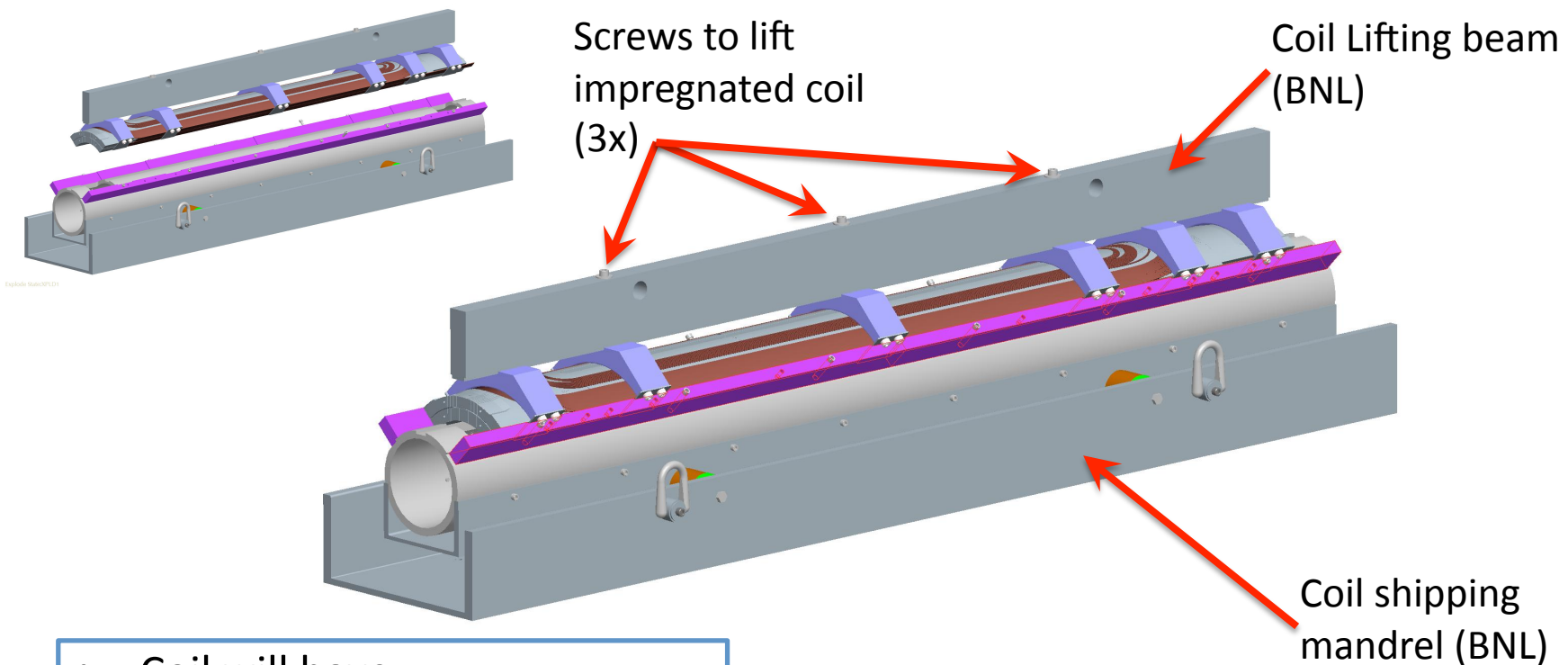


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# Coil Prep, From Shipping to Instrumentation

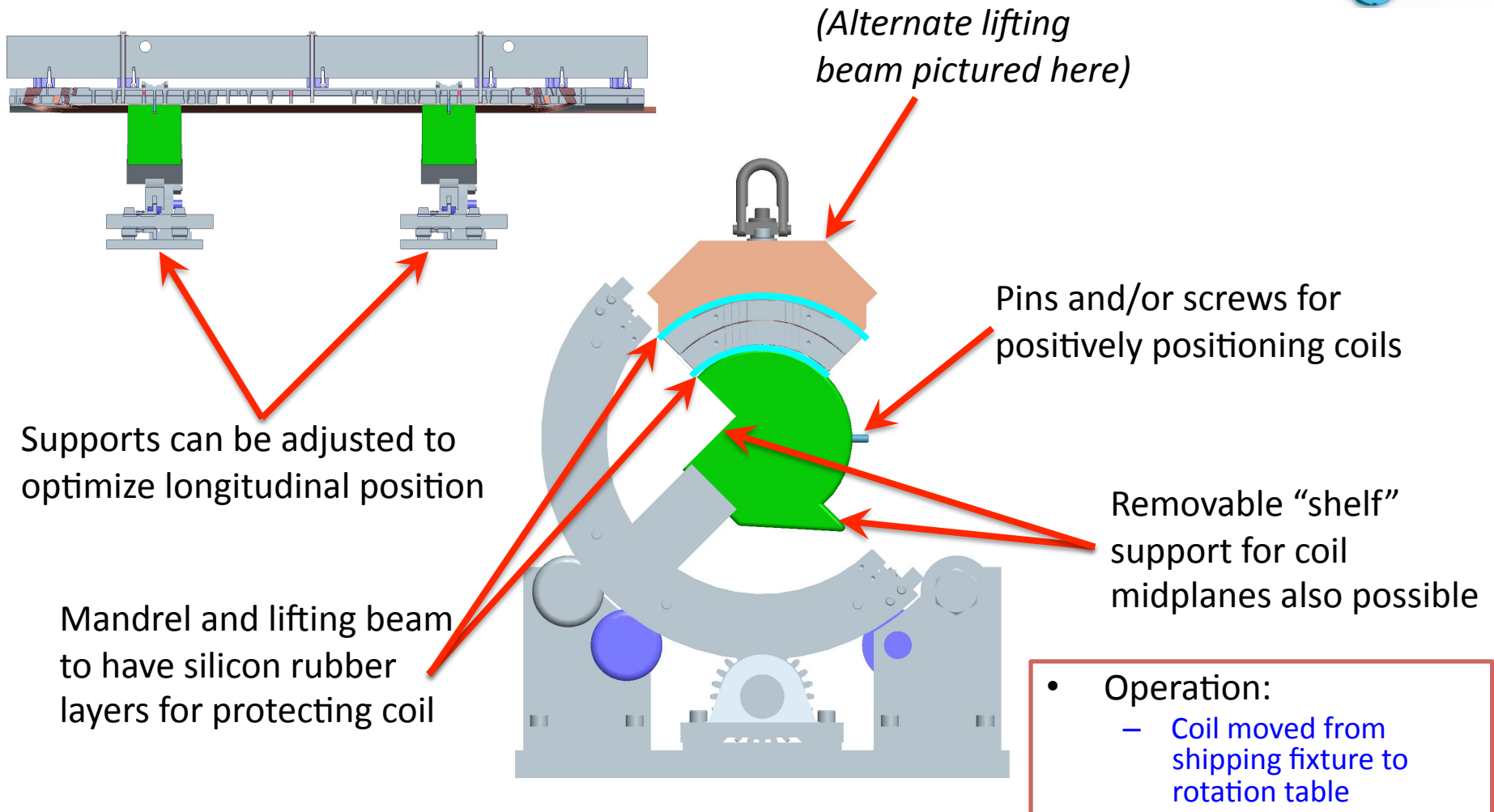


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- Coil will have:
  - VT wires attached
  - No SGs or GPI

# Coil Prep, From Shipping to Instrumentation



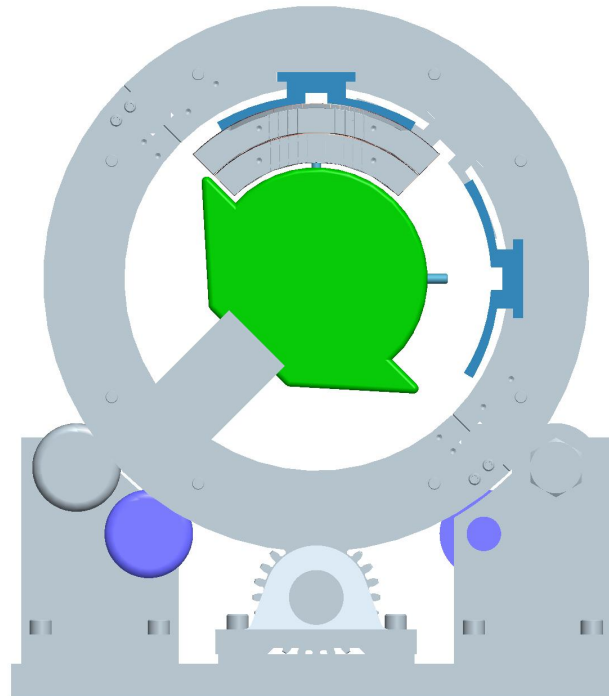


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# Coil Prep, From Shipping to Instrumentation



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- Coil will have:
  - VT wires attached
  - No SGs or GPI

- Operation:
  - Clamp rings placed over coil



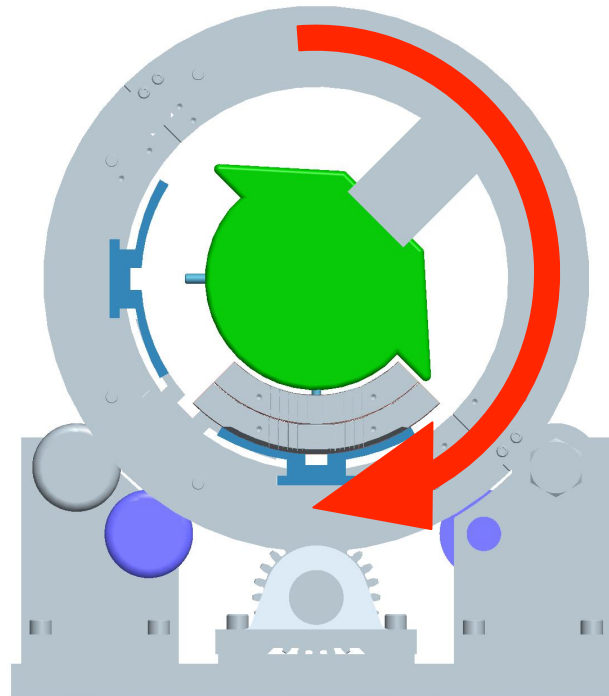


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# Coil Prep, From Shipping to Instrumentation



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- Coil will have:
  - VT wires attached
  - No SGs or GPI

- Operation:
  - Wheel assembly rotated 180°

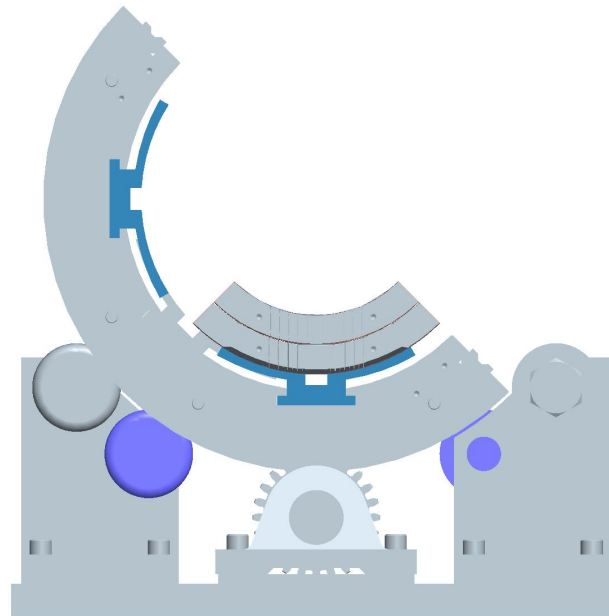


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# Coil Prep, From Shipping to Instrumentation



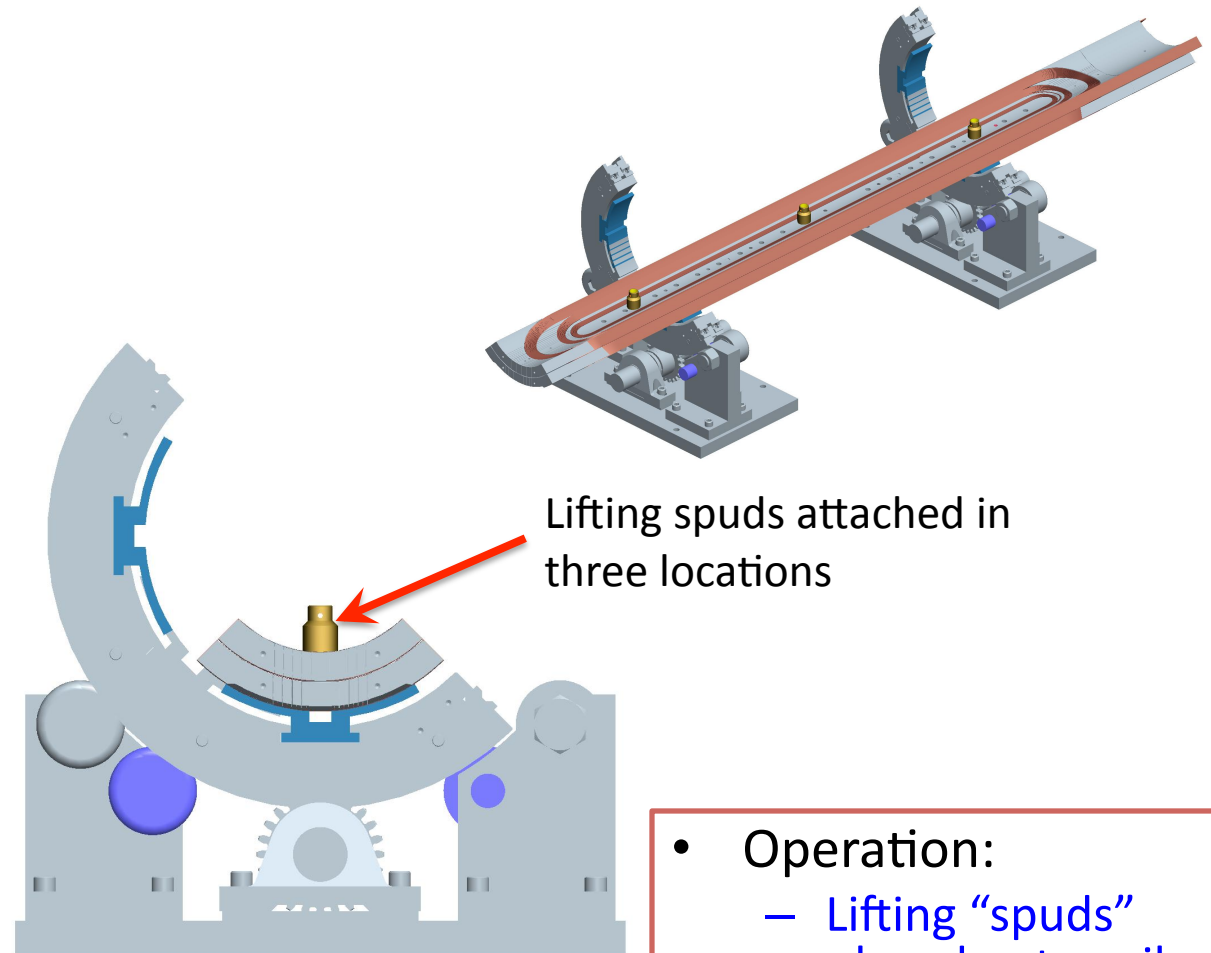
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- Coil will have:
  - VT wires attached
  - No SGs or GPI

- Operation:
  - Clamp & mandrel removed

# Coil Prep, From Shipping to Instrumentation



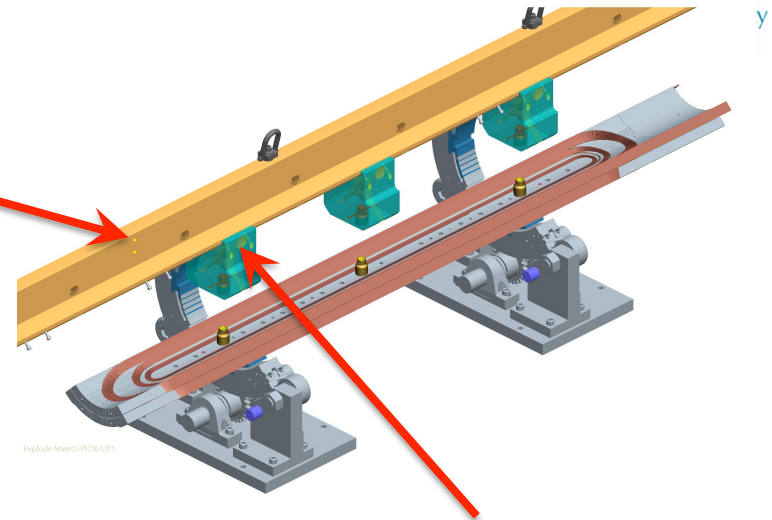
- Coil will have:
  - VT wires attached
  - No SGs or GPI

- Operation:
  - Lifting “spuds” placed onto coil

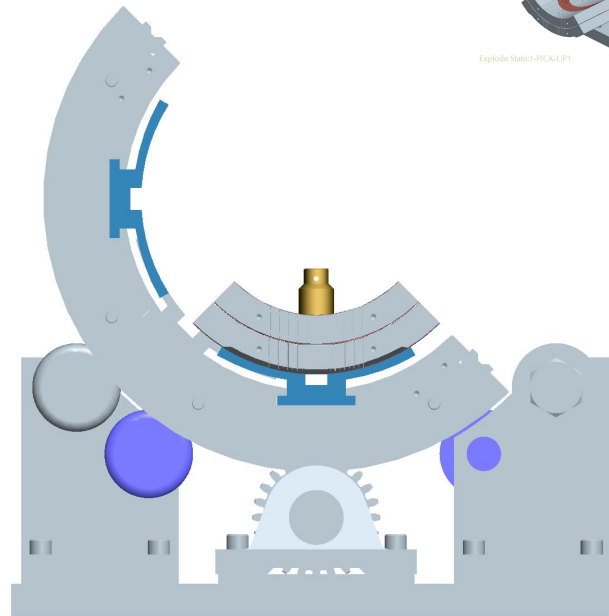
# Coil Prep, From Shipping to Instrumentation



Recycled LQ coil lifting  
strongback (~3.3 m)



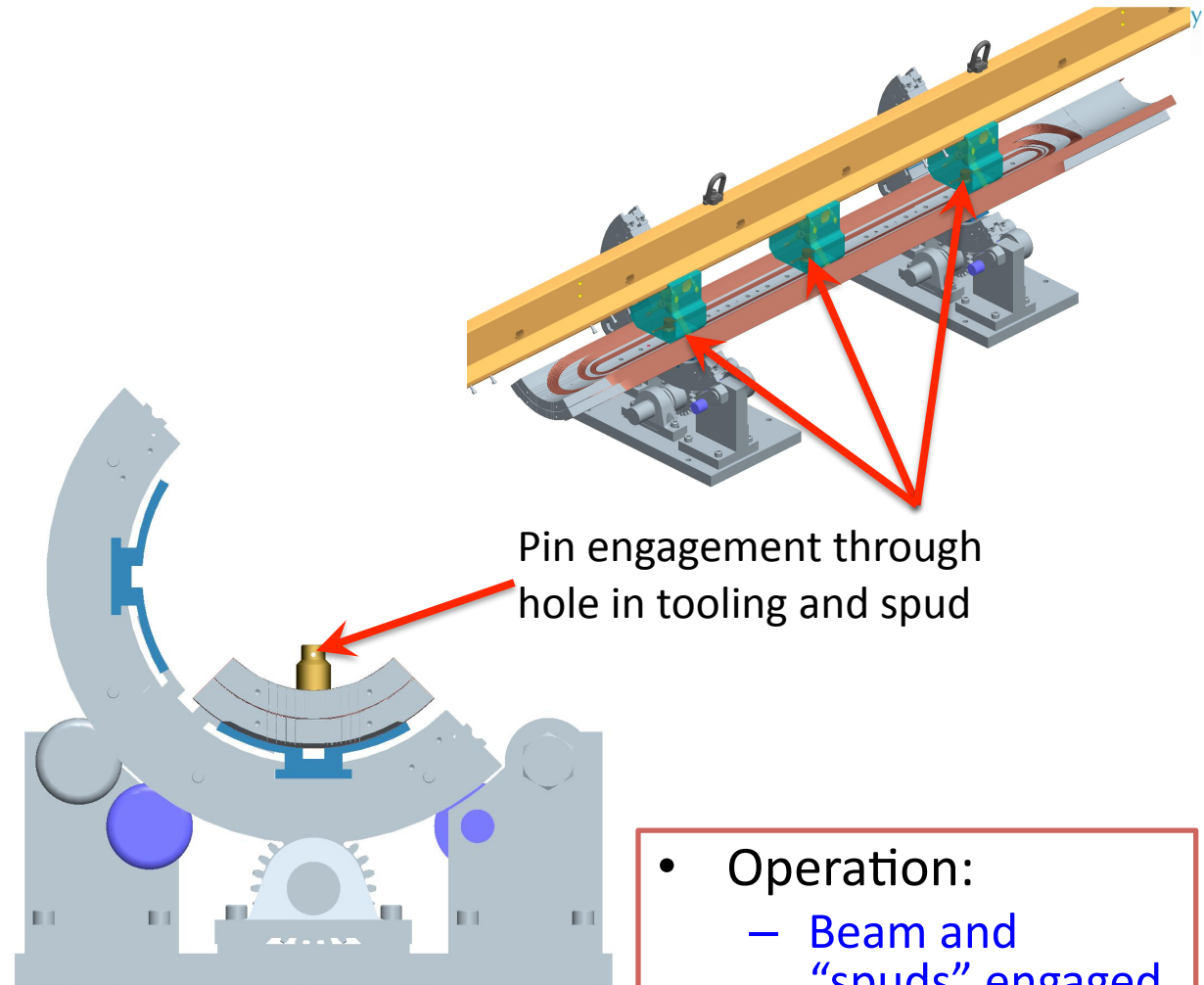
Redesigned coil interfaces,  
3 places



- Coil will have:
  - VT wires attached
  - No SGs or GPI

- Operation:
  - Coil lifting beam brought to coil

# Coil Prep, From Shipping to Instrumentation



- Coil will have:
  - VT wires attached
  - No SGs or GPI

- Operation:
  - Beam and “spuds” engaged via inserted pins

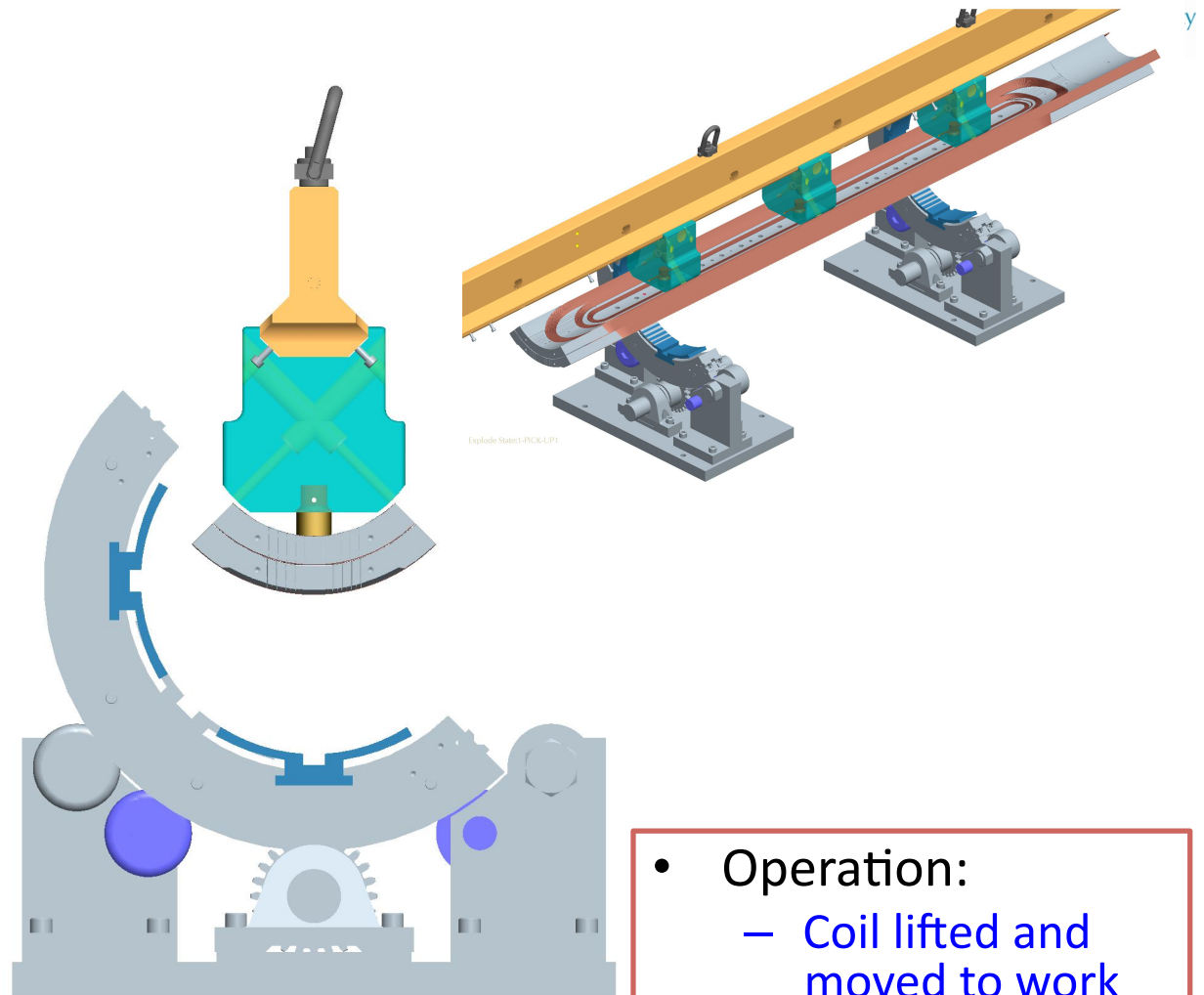


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# Coil Prep, From Shipping to Instrumentation



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*Later steps not shown:  
Strain gage installation,  
Wiring & connectorization,  
QA*

- Coil will have:
  - VT wires attached
  - No SGs or GPI

- Operation:
  - Coil lifted and moved to work area



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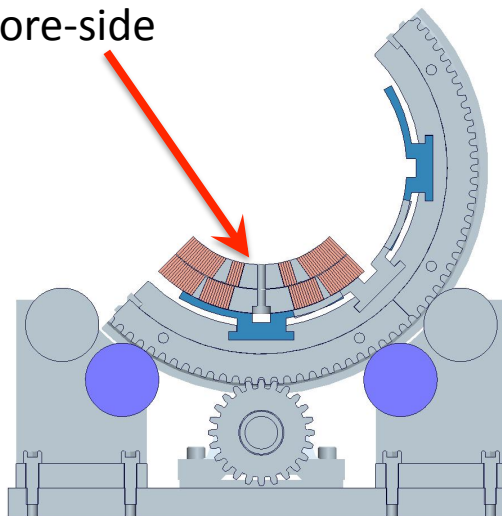
## Intermediate Coil Steps, Before Assembly



- Between receiving coils and assembly, a number of steps will have occurred (but not described here)
  - Coils will be instrumented with SGs
  - Wiring and connectors will be added
  - Coil QA will be performed
  - Coils will go into storage trays, bore-side up

# Coil Prep, From Storage to GPI Installation

Strain gages and wiring will  
be mounted on bore-side



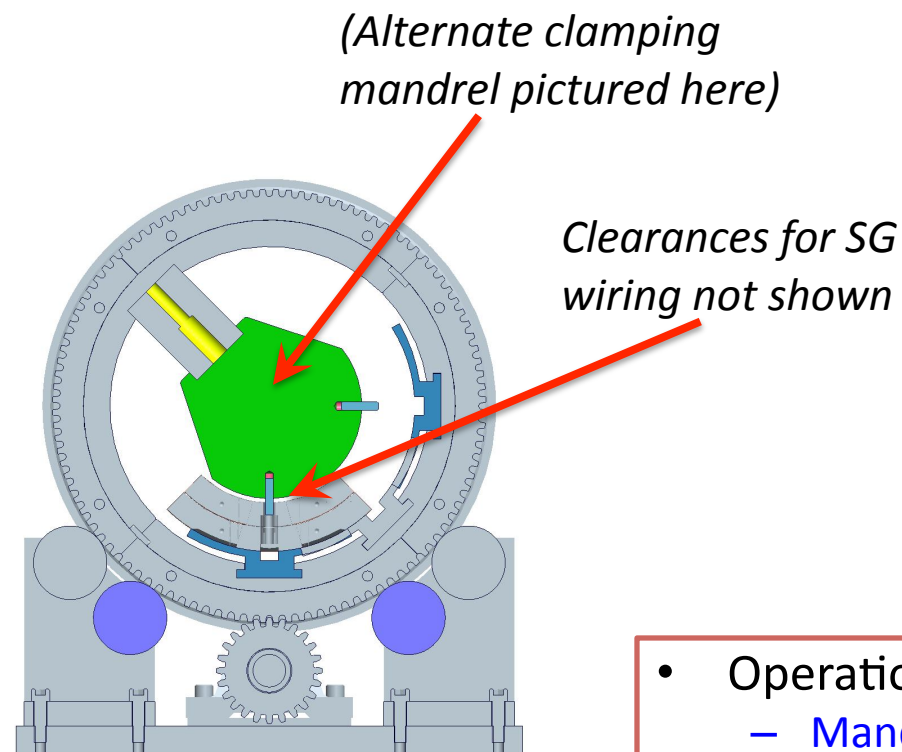
- Coil will have:
  - VT wires attached
  - SG & wires on bore-side
  - No GPI

*Steps not shown:  
Coil lifted and moved from  
storage tray*

- Operation:
  - Coil placed into  
rotation wheel



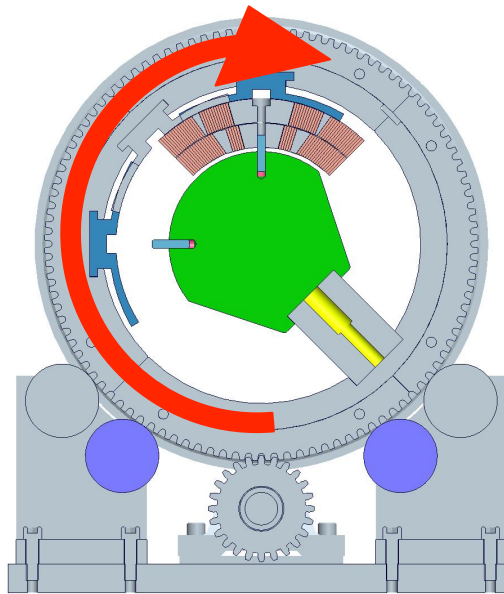
# Coil Prep, From Storage to GPI Installation



- Coil will have:
  - VT wires attached
  - SG & wires on bore-side
  - No GPI

- Operation:
  - Mandrel & clamps installed over coil

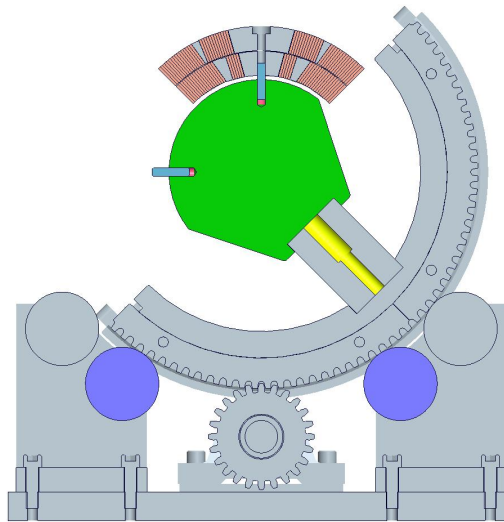
# Coil Prep, From Storage to GPI Installation



- Coil will have:
  - VT wires attached
  - SG & wires on bore-side
  - No GPI

- Operation:
  - Rotation wheel rotated 180°

# Coil Prep, From Storage to GPI Installation



- Coil will have:
  - VT wires attached
  - SG & wires on bore-side
  - No GPI

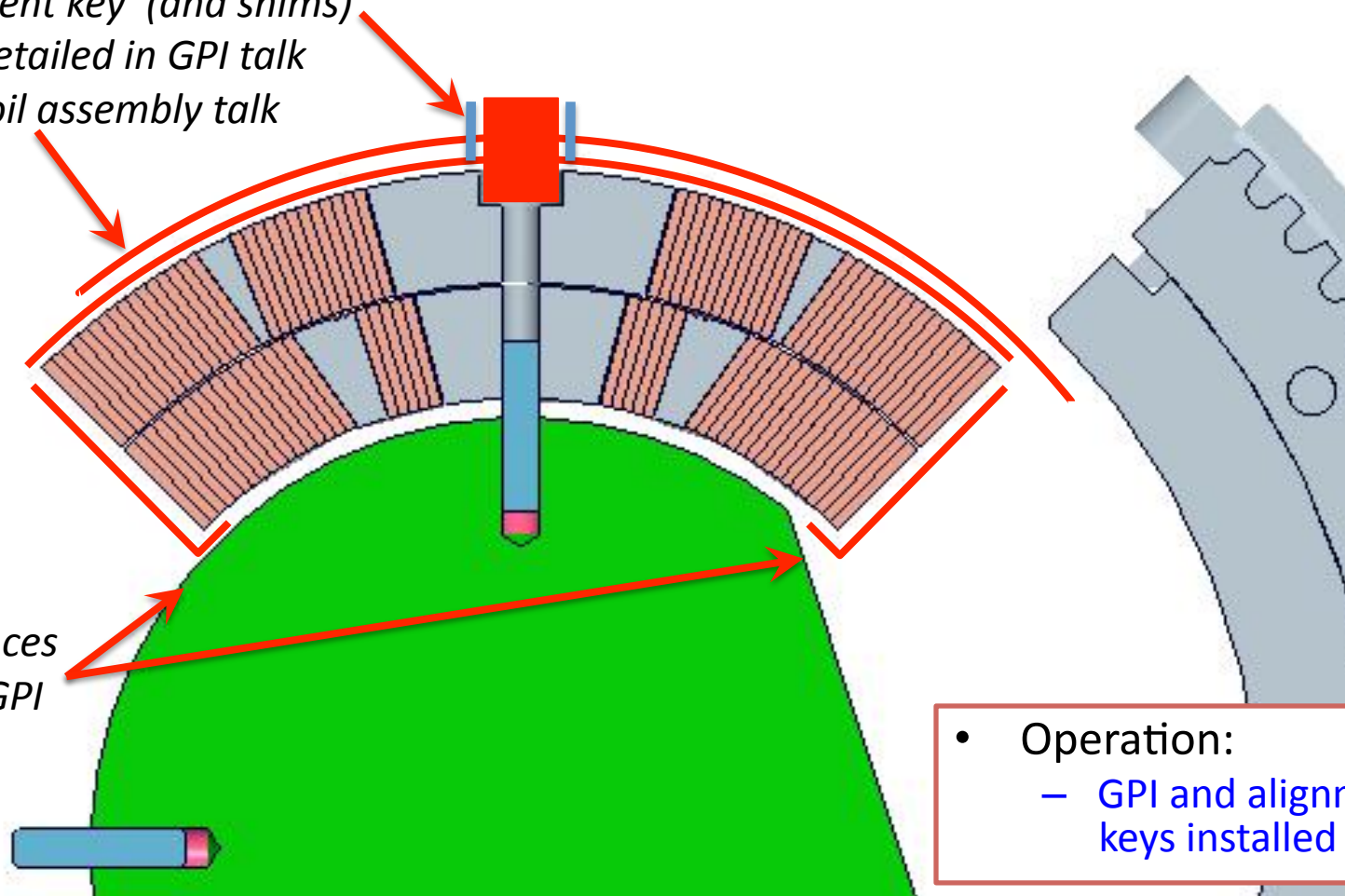
- Operation:
  - Clamps removed from around coil

# GPI, Alignment Key Installation

*For diagram purposes only.*

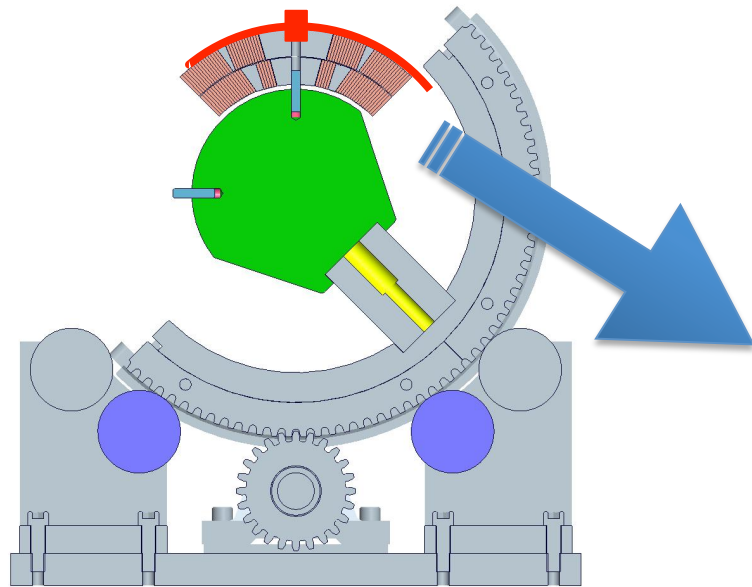
*GPI & Alignment key (and shims)  
installation detailed in GPI talk  
(Jesse) and coil assembly talk  
(Helene)*

*Relief clearances  
required for GPI  
installation*



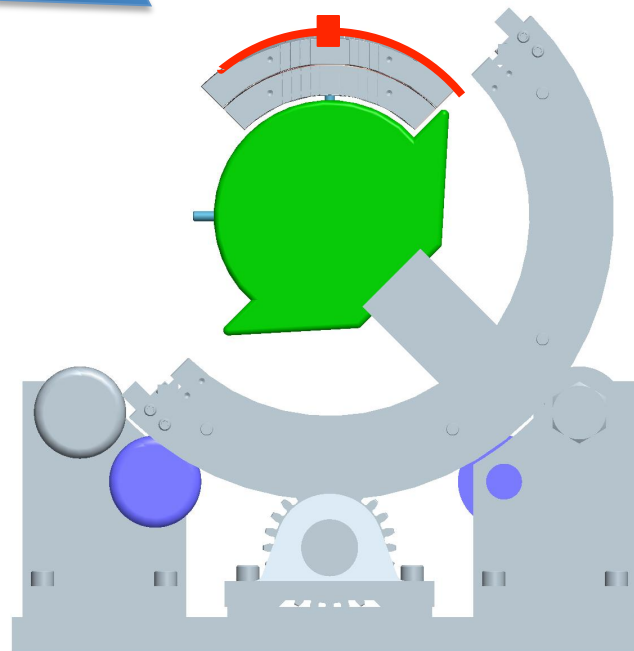
- Operation:
  - GPI and alignment keys installed

# Coilpack Assembly, Pairing Bottom Coils



*Second Rotation wheel  
assembly*

- Coil will have:
  - VT wires attached
  - SG & wires on bore-side
  - GPI and alignment key



- Operation:
  - Move coil from 2<sup>nd</sup> rotation wheel

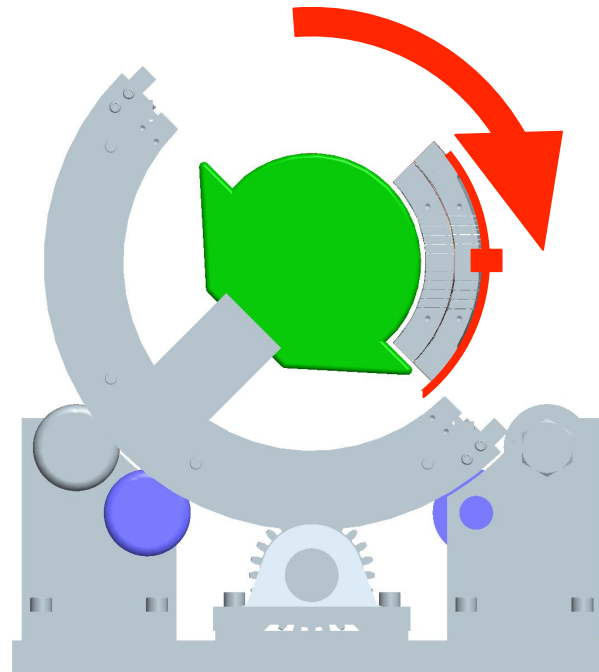


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# Coilpack Assembly, Pairing Bottom Coils



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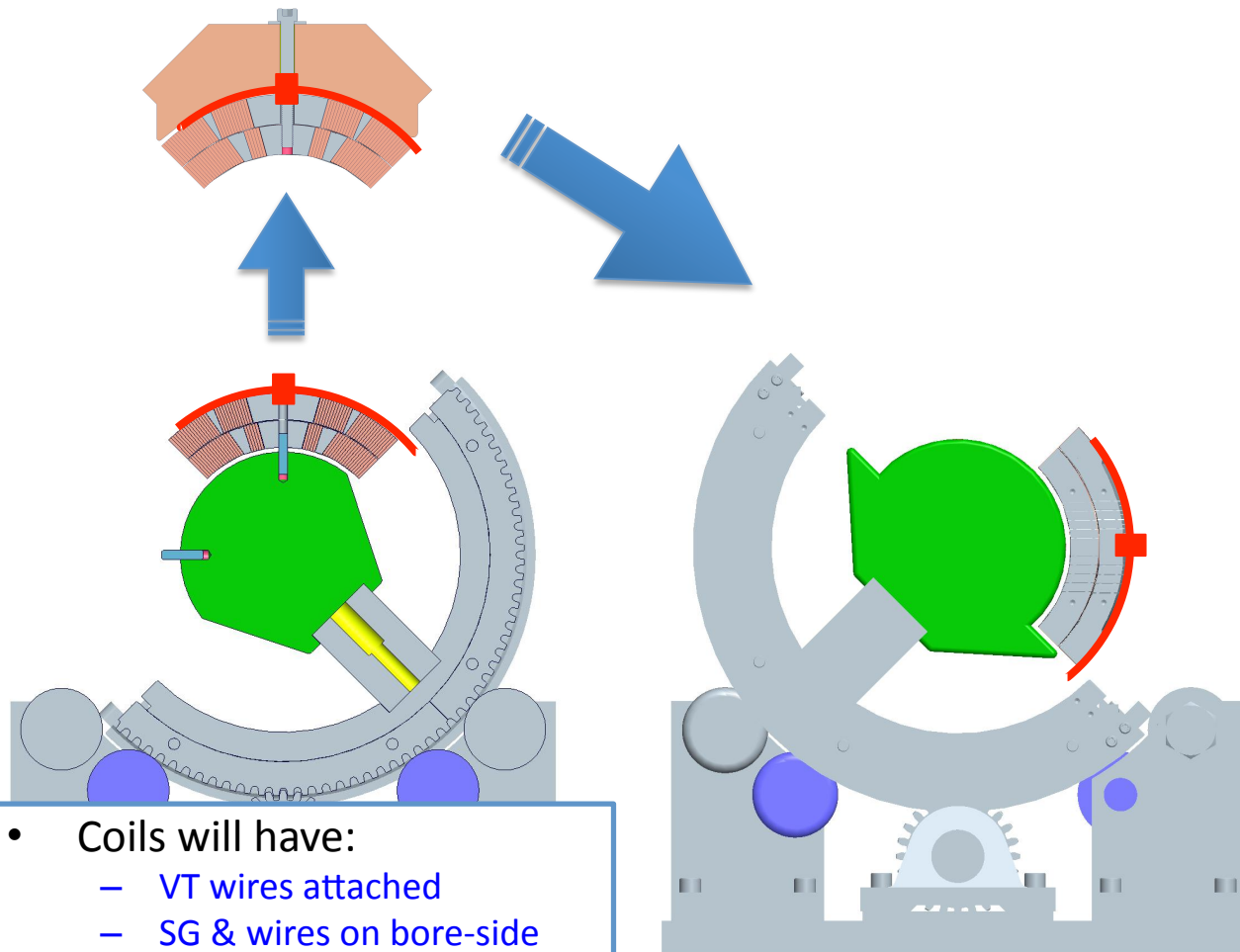


- Coil will have:
  - VT wires attached
  - SG & wires on bore-side
  - GPI and alignment key

*Note: Coil may have clamps installed, or may be bolted thru during rotation operation*

- Operation:
  - Rotate coil by 45°

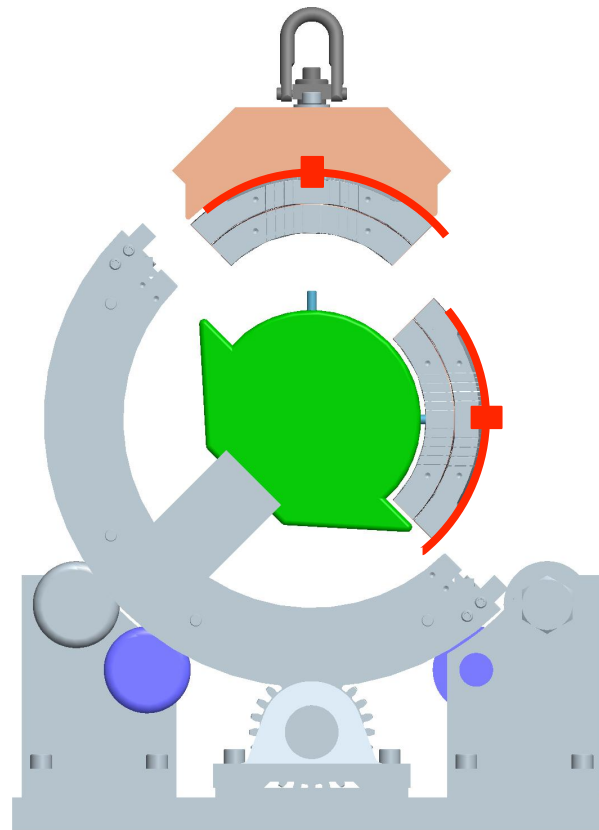
# Coilpack Assembly, Pairing Bottom Coils



- Coils will have:
  - VT wires attached
  - SG & wires on bore-side
  - GPI and alignment key

- Operation:
  - Pick up second coil with GPI/key

# Coilpack Assembly, Pairing Bottom Coils



- Coils will have:
  - VT wires attached
  - SG & wires on bore-side
  - GPI and alignment key

- Operation:
  - Mate second coil to the first one at 45°



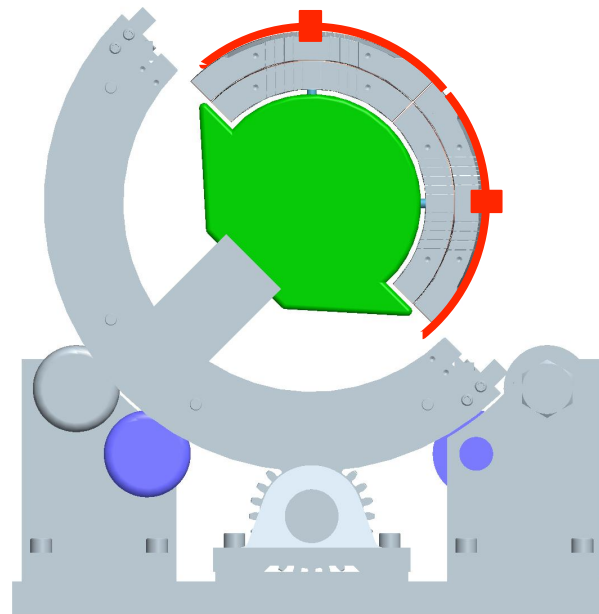


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# Coilpack Assembly, Pairing Bottom Coils



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- Coils will have:
  - VT wires attached
  - SG & wires on bore-side
  - GPI and alignment key

- Operation:
  - Mate second coil to the first one at 45°

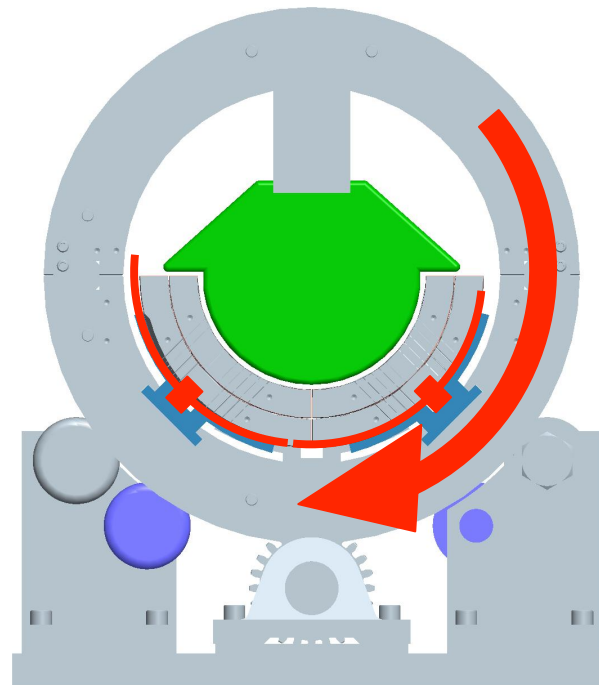


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# Coilpack Assembly, Pairing Bottom Coils



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- Coils will have:
  - VT wires attached
  - SG & wires on bore-side
  - GPI and alignment key

- Operation:
  - Replace clamps and rotate coils 135°

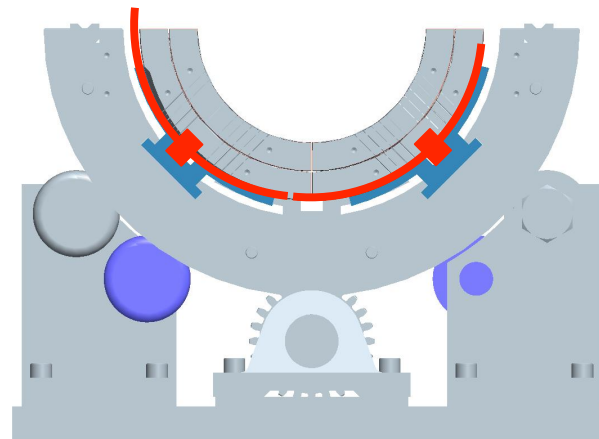


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# Coilpack Assembly, Pairing Bottom Coils



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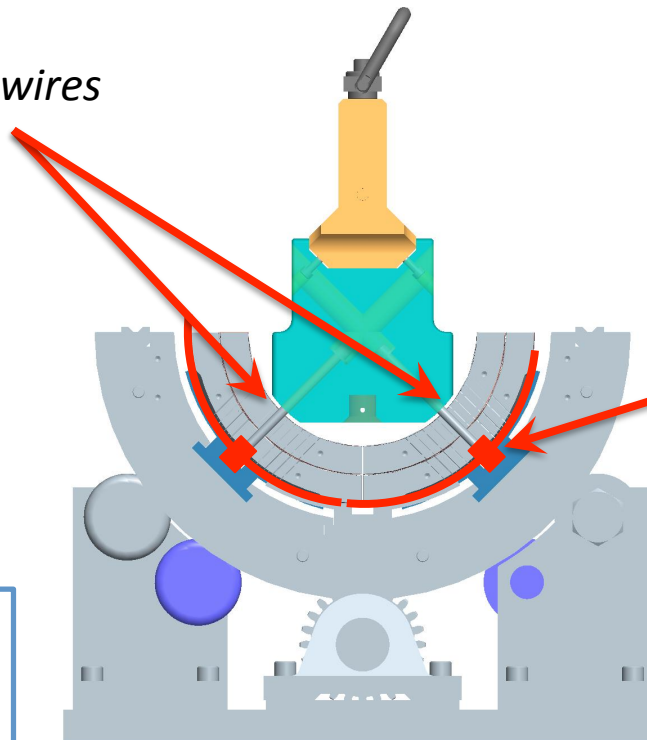


- Coils will have:
  - VT wires attached
  - SG & wires on bore-side
  - GPI and alignment key

- Operation:
  - Remove clamps and mandrel support

# Coilpack Assembly, Pairing Bottom Coils

*Clearances for SG wires  
may be necessary*

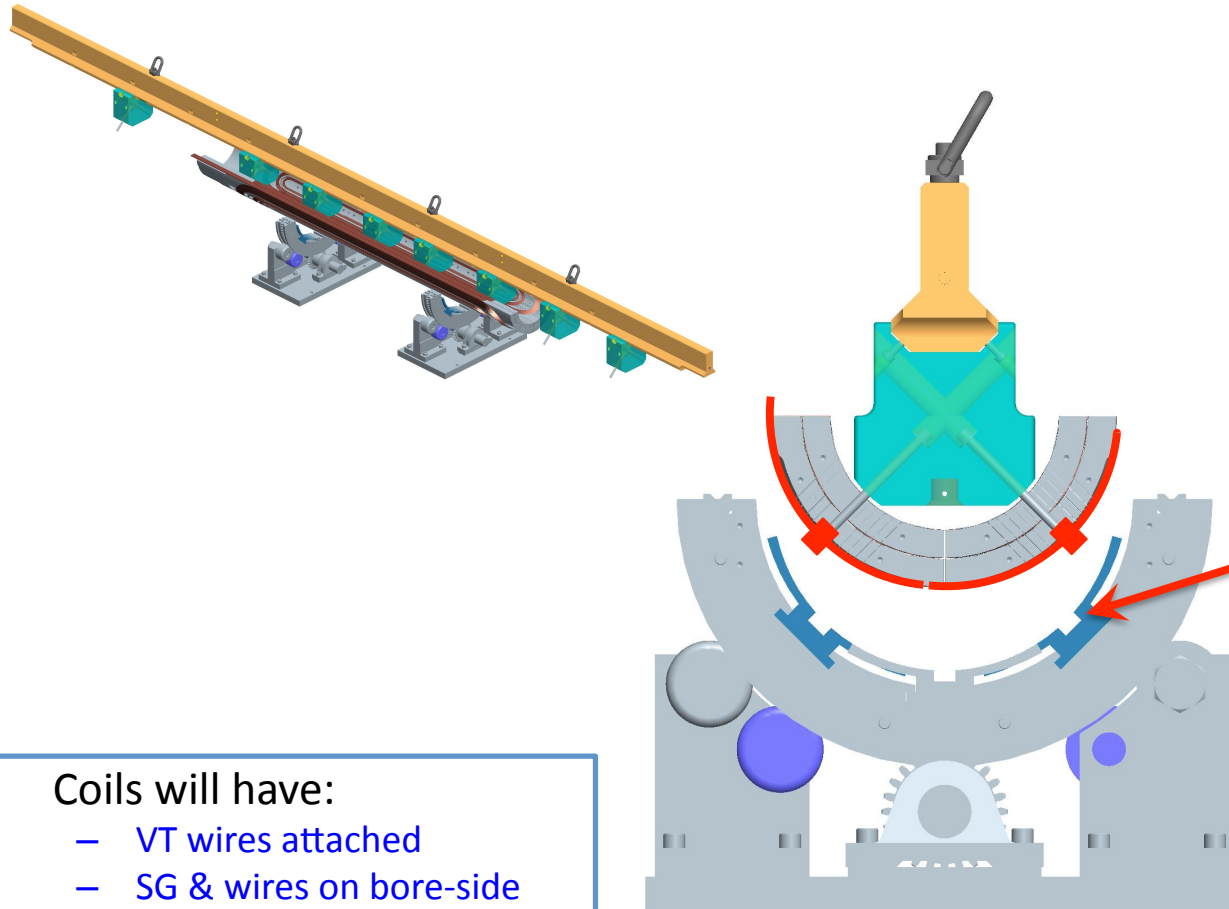


*Clamps may need to be  
removed during lifting  
operation, due to  
presence of alignment  
keys*

- Coils will have:
  - VT wires attached
  - SG & wires on bore-side
  - GPI and alignment key

- Operation:
  - Attach lifting beam to coil pair

# Coilpack Assembly, Pairing Bottom Coils

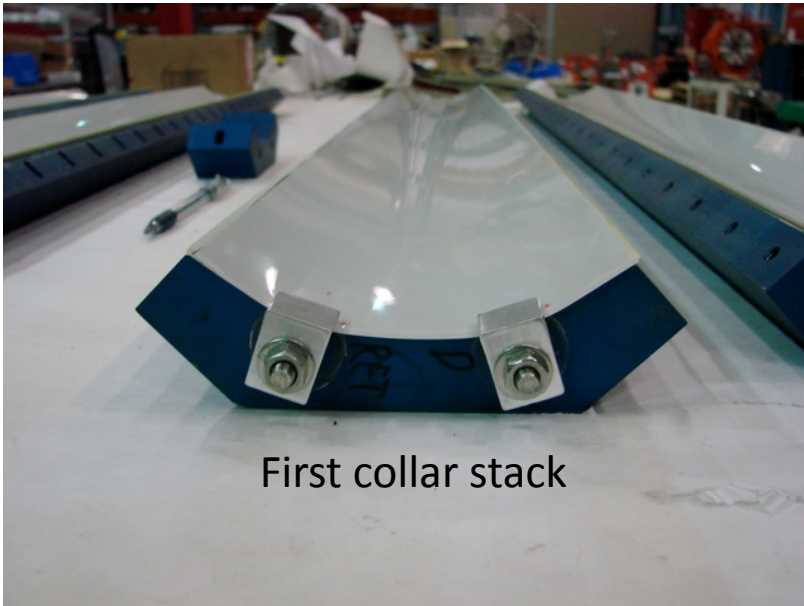


*Clamps may need to either be modified, or removed during lifting operation, due to presence of alignment keys*

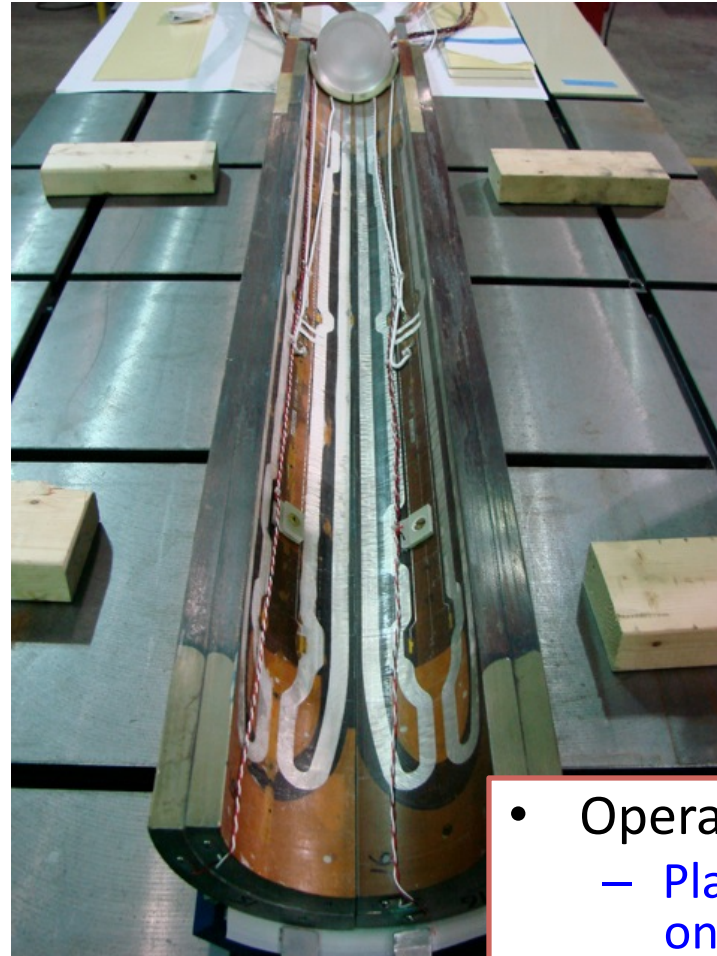
- Coils will have:
  - VT wires attached
  - SG & wires on bore-side
  - GPI and alignment key

- Operation:
  - Lift coil pair; move to collar stack

# Coilpack Assembly, Pairing Bottom Coils (HQ)



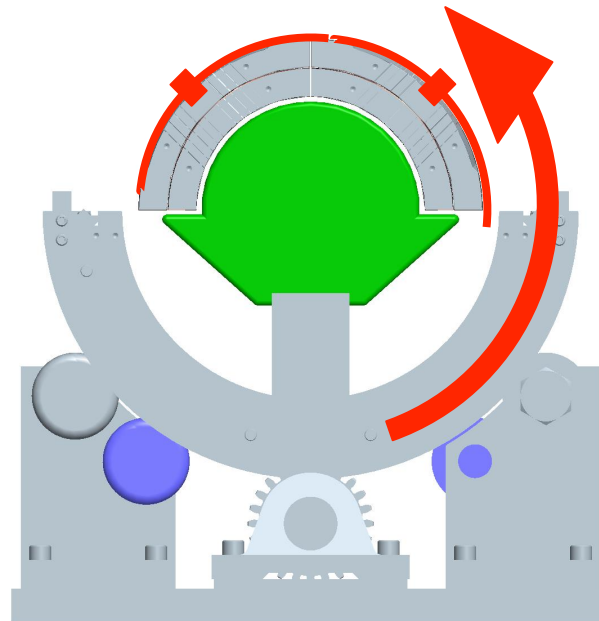
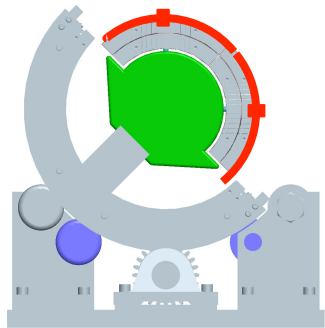
First collar stack



- Coils will have:
  - VT wires attached
  - SG & wires on bore-side
  - GPI and alignment key
- Collars will have:
  - Additional Kapton/G11 layers

- Operation:
  - Place coil pair onto collar stack

# Coilpack Assembly, Pairing Upper Coils



- Coils will have:
  - VT wires attached
  - SG & wires on bore-side
  - GPI and alignment key

- Operation:
  - Rotate coils by 45° opposite direction

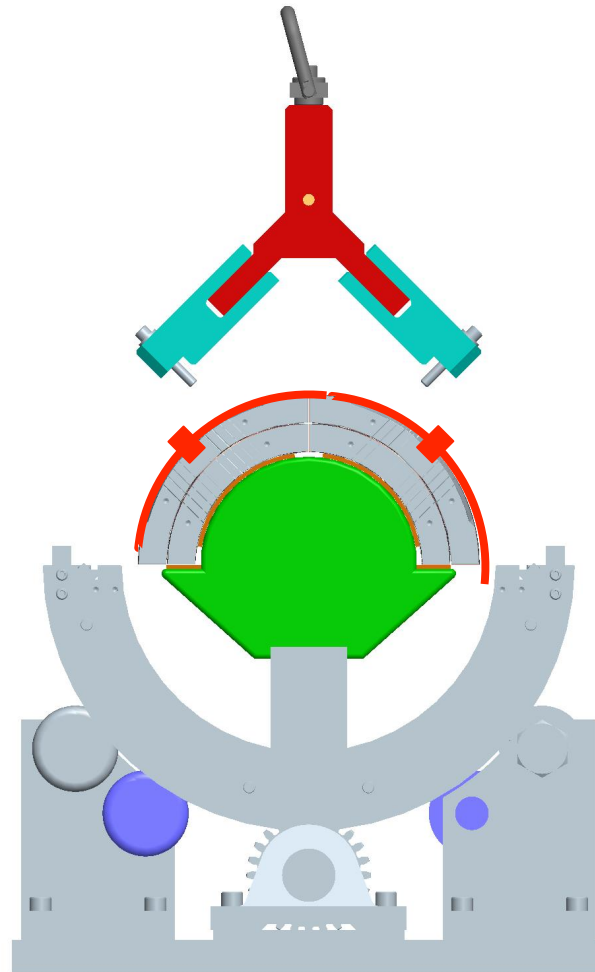


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# Coilpack Assembly, Pairing Upper Coils



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- Coils will have:
  - VT wires attached
  - SG & wires on bore-side
  - GPI and alignment key

- Operation:
  - Align coil pair
  - lifting strongback



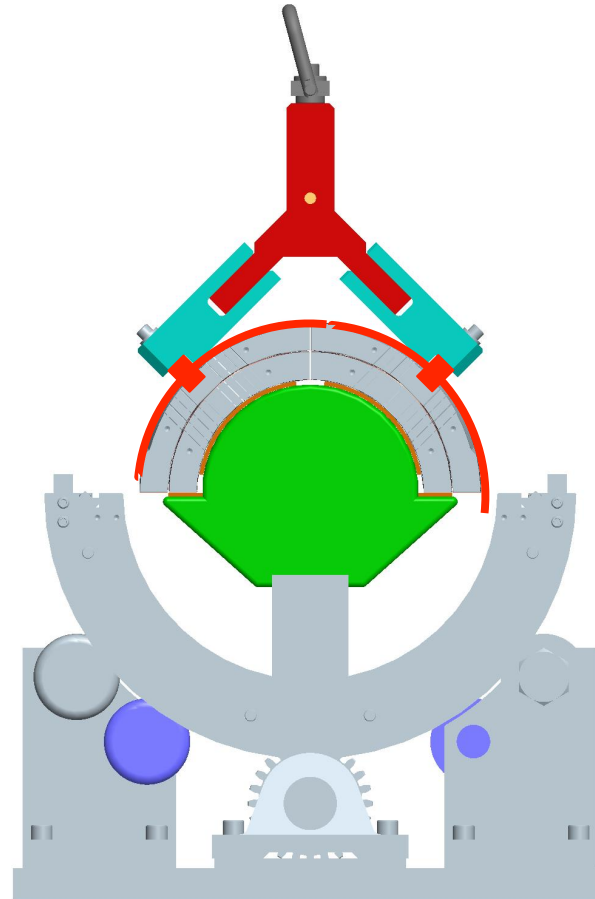


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# Coilpack Assembly, Pairing Upper Coils



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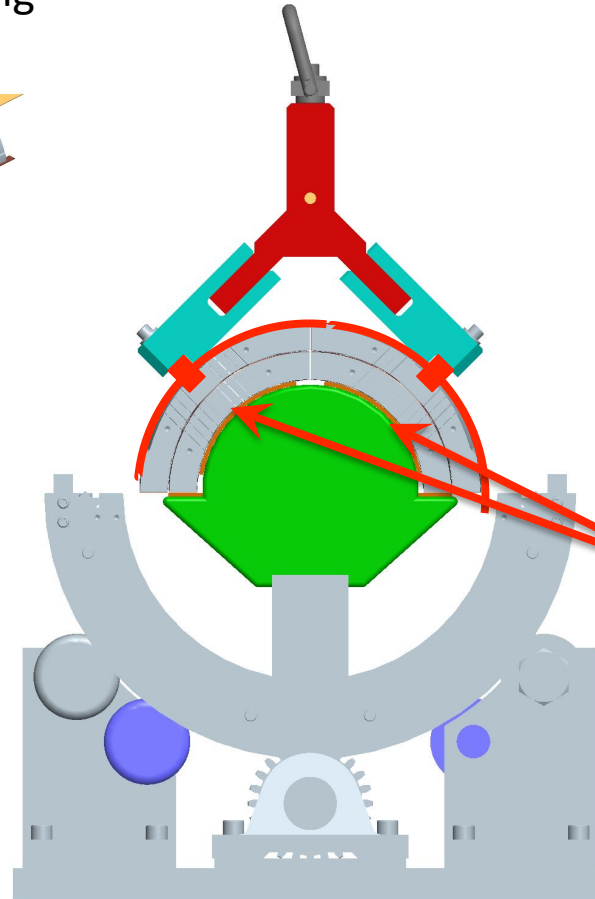
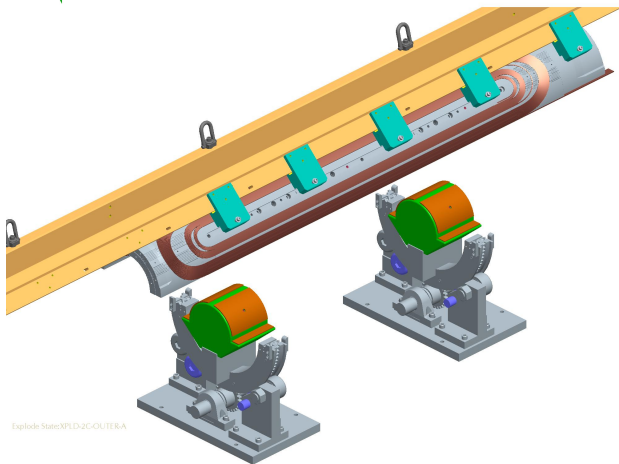
- Coils will have:
  - VT wires attached
  - SG & wires on bore-side
  - GPI and alignment key

- Operation:
  - Attach coil pair
  - lifting strongback

# Coilpack Assembly, Pairing Upper Coils



Recycled LQ coil pair lifting  
strongback (~3.3 m)

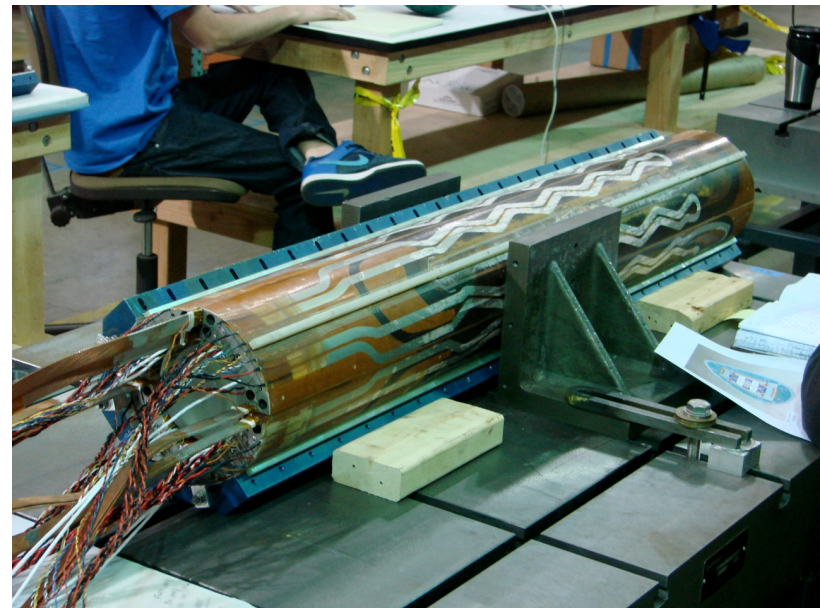
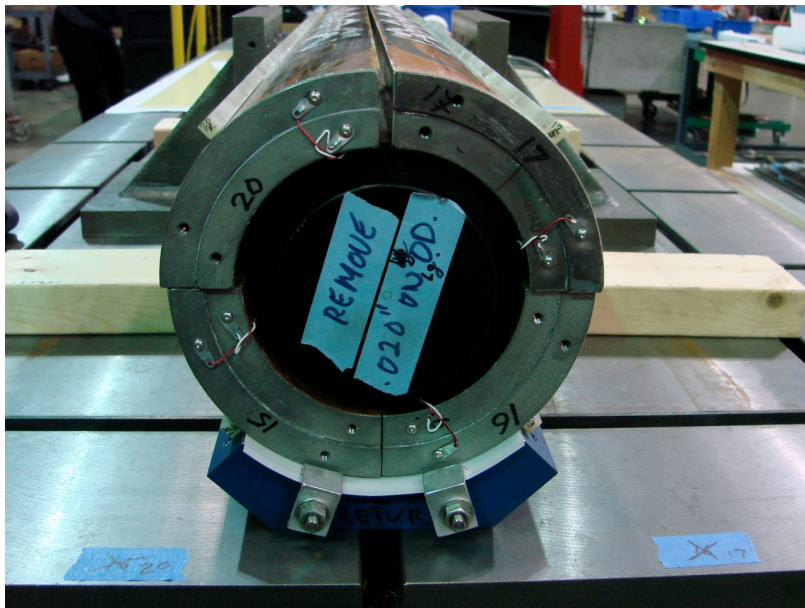


*Hold down tooling  
(bolts, pins) may have  
to be removed before  
coils can be lifted*

- Coils will have:
  - VT wires attached
  - SG & wires on bore-side
  - GPI and alignment key

- Operation:
  - Lift coil pair with  
lifting strongback

# Upper Coils & Collaring Assembly (HQ)

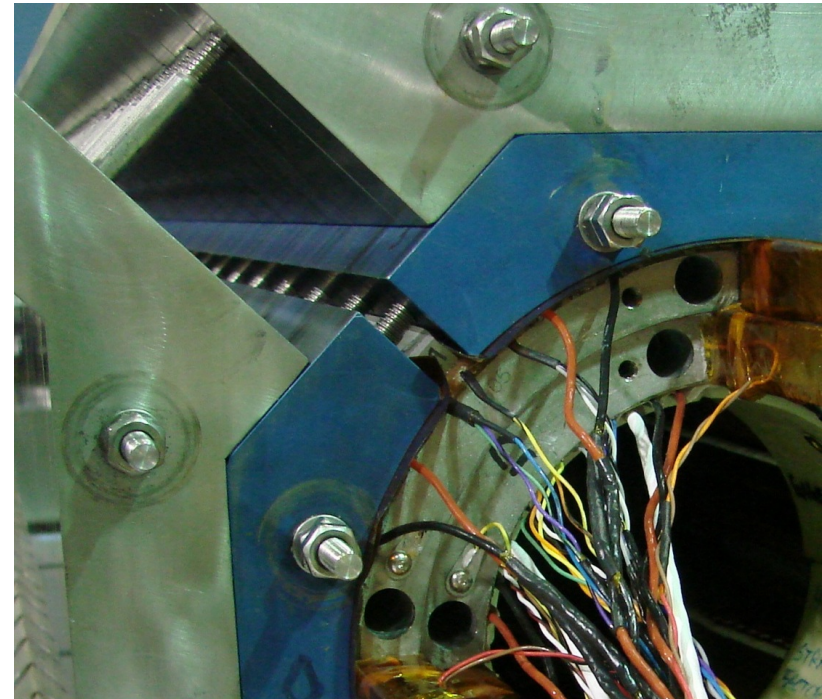


- Coils will have:
  - VT wires attached
  - SG & wires on bore-side
  - GPI and alignment key

- Operation:
  - Mate coil pairs together
  - Support with angle irons



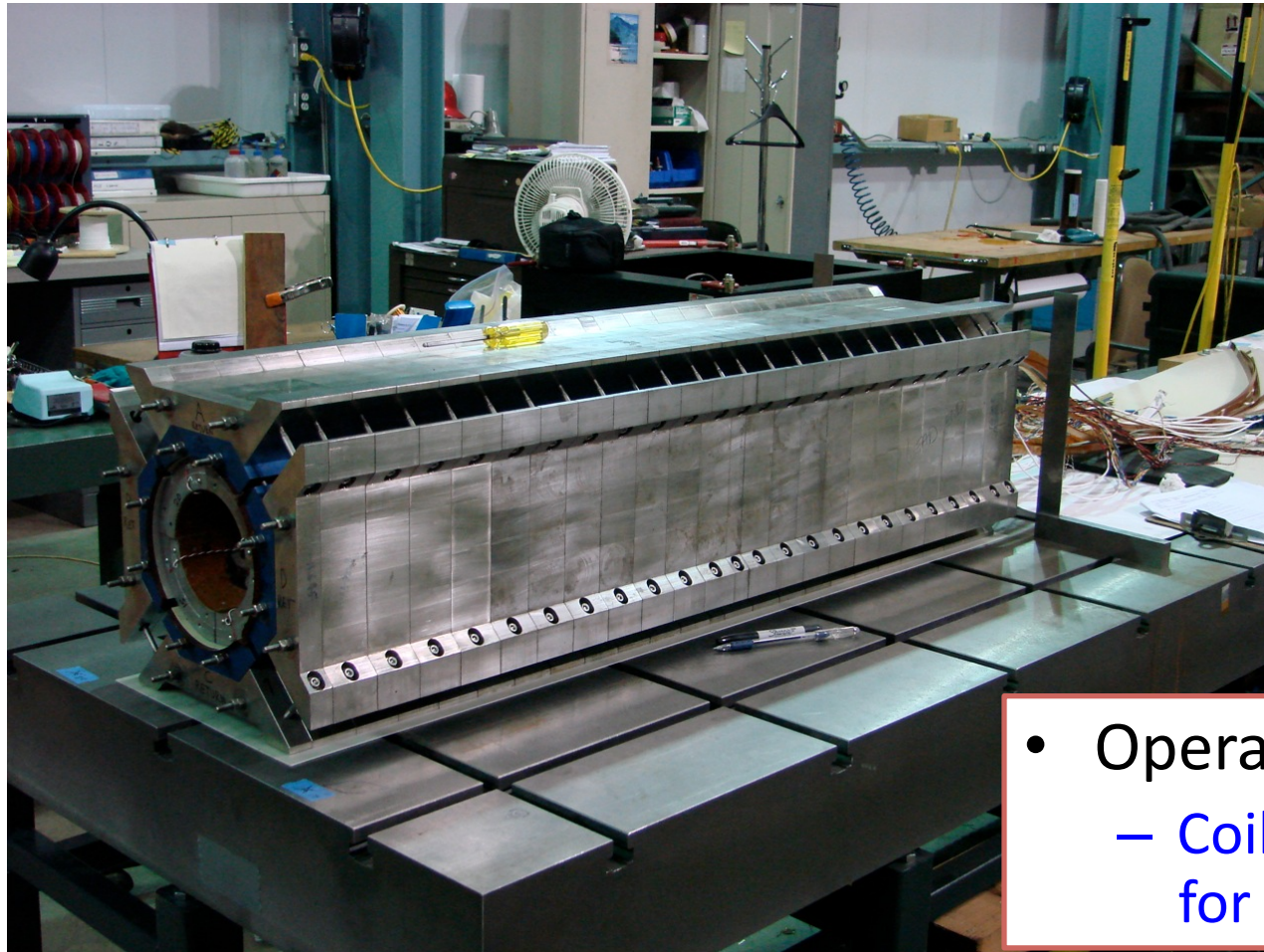
# Upper Coils & Collaring Assembly (HQ)



- Coils will have:
  - VT wires attached
  - SG & wires on bore-side
  - GPI and alignment key
- Collars will have:
  - Additional Kapton/G11 layers

- Operation:
  - Bolt collars (with shims, GPI, etc.)
  - Bolt load pads

# Coilpack Assembly, Collar Assembly (HQ)



- Operation:
  - Coilpack ready for insertion



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# Tooling and Assembly Concept Summary



- Conceptual SQXF coilpack assembly steps presented
  - Key interfaces identified at operation stages
- Reuses exiting tooling designs
  - LQ lifting hardware (for SQXF), however for LQXF may require new tooling
  - FNAL rollover tooling will have modifications made to accommodate the SQXF coils
- Scalability
  - Both SQXF rollover tables can be reconfigured to accommodate one LQXF coil, and one more set can be purchased for the second rollover assembly needed in LQXF
  - LQ lifting hardware can either be extended to accommodate 4.3m long coils, or...
  - (Preferable) New, dedicated strongbacks can be designed